Express Mail:
EV398341251US

RECURRENT REFLECTIVE SYNTHETIC FILAMENT YARN AND METHOD OF PRODUCING THE SAME

Cross-Reference

This application is a Continuation-In-Part of copending U.S. Application No. 10/150,697.

Field Of The Invention

The present invention pertains, in general, to a reflective yarn and more particularly, the present invention relates to a recurrent reflective synthetic filament yarn including spherical glass beads that are vacuum-metalized.

Description of the Prior Art

Generally, reflective materials having a reflective function are widely used in safety applications for preventing accidents and securing safe conditions, and demands for these reflective materials have been growing rapidly. For example, when a traffic policeman or a street sweeper works at night, or when an elderly or very young person is exposed to vehicles at night, it is difficult for a driver to recognize them, and so a loss of life may result.

To reduce the risk, therefore, materials having the reflective function are applied to various traffic signs, miscellaneous goods such as sportswear, sporting goods, and bags, and military recognition signs.

Meanwhile, various studies have been made of materials having a high reflective index as well as materials reflecting light. For example, a film or sheet shape of reflective materials are widely used commercially. However, a yarn shape of the reflective material is not commercially produced, and thus the reflective material has hardly been applied to threads or textiles.

One example of conventional reflective fibers includes the film or sheet shape of reflective materials as illustrated in FIGS. 1 and 2. However, the film or sheet shape of reflective materials are not fabric but a film or sheet with or without a slit surface. In other words, a reflective sheet is produced by coating an aluminum paste as a reflective film on any one side of a thin synthetic resin sheet 60 to form a coating layer 70, as shown in FIG. 1. However, the reflective sheet has disadvantages in that the reflective index and reflection brightness are practically weak because irregular reflection occurs through the reflective film, thus the reflective sheet is not suitable for commercial use, and reflection efficiency is rapidly reduced and color fastness to washing is low because the

aluminum coating layer 70 is easily removed from the synthetic resin sheet or easily damaged.

Furthermore, a reflective sheet may be produced by coating an aluminum paste as a reflective film on any one side of a thin synthetic resin sheet 60 to form a coating layer 70 and coating a mixture of transparent polyurethane and glass beads 40 on the aluminum coating layer 70, as shown in FIG. 2. However, the reflective sheet has disadvantages in that the synthetic resin sheet can be applied with limits to clothes, have a poor texture and color fastness to washing, are reduced in workability, and are difficult to apply to embroidery yarn because the synthetic resin sheet is made of a hard material, such as polyethylene terephthalate or polyvinyl chloride, even though recurrent reflection can be feasible and reflection efficiency is good.

Synthetic resin fabric may be used instead of the synthetic resin sheet 60. However, the synthetic resin fabric is disadvantageous in that texture, workability, and color fastness to washing are poor, and the synthetic resin fabric cannot be widely applied even though reflection efficiency is good.

With respect to the synthetic resin fabric, a reflective woven fabric is disclosed in U.S. Pat. No. 4,187,332, which is produced by coating reflective glass

beads on a woven fabric and drying the resulting woven fabric.

Another example of the conventional reflective fibers is a slit reflective film or sheet, or a slit thread. In this respect, an aluminum paste layer as a reflective layer is coated on any one side of a thin synthetic resin film or sheet, a mixture of transparent polyurethane or an adhesive and glass beads is coated on the aluminum paste layer to produce the reflective film or sheet, and the reflective film or sheet thus produced is longitudinally slit in such a way that a width of the reflective film or sheet is 0.25 to 0.37 mm for the narrow reflective film or sheet, or 3 to 5 mm for the wide reflective film or sheet. At this time, the slit reflective film or sheet is doubled or twisted with a synthetic yarn to produce the slit thread. However, the slit reflective film or sheet, or the slit thread is readily broken because of the weak tensile strength thereof, and even if it is doubled or twisted, its tensile strength is improved but its texture is poorer than that of fiber. Further, the slit reflective film or sheet, or the slit thread has disadvantages in that the aluminum paste layer or the glass beads are easily separated from the synthetic resin film or sheet, or readily damaged. Furthermore, the slit reflective film or sheet, or the slit thread is used as tapes or plates, but not as textiles. Strictly speaking,

therefore, the slit reflective film or sheet, or the slit thread cannot be included in textiles.

For example, U.S. Pat. No. 4,336,092 discloses a process of producing a recurrent reflective thread including coating a thin film type of recurrent reflecting agent on a polyester film, slitting the resulting polyester film in a shape of thin strips, and mixing the strips with other fibers. Additionally, U.S. Pat. No. 4,546,042 recites a recurrent reflective thread produced by thinly cutting a sheet coated with a recurrent reflecting agent. However, it is impossible to use this recurrent reflective thread as a grey yarn for textiles.

Accordingly, there is a need to develop a filament yarn with an excellent reflective function, which secures all functions required as the filament yarn and is not produced by slitting a film or a sheet.

To meet the above need, Korean Pat. No. 10-355011 suggests the production of a recurrent reflective grey yarn according to a conjugate spinning process. According to this patent, a mixture of a recurrent reflective material including glass beads or mica, and a first polymer material capable of being spun is mixed with a second polymer material capable of being spun in a voluminal mixing ratio of 5 to 95 : 95 to 5, and then subjected to the conjugate spinning process to produce a recurrent reflective filament.

However, this patent is disadvantageous in that a very complicated process is required to produce the recurrent reflective filament, and it is impossible to produce a thinner grey yarn than a fishline through a technology as described in this patent, thus the recurrent reflective filament cannot be applied as the grey yarn to an embroidery, a sewing, a weaving, and a knitting.

SUMMARY OF THE INVENTION

According to one aspect of the invention, a recurrent reflective synthetic filament yarn product is produced by the following process including the step of melt-spinning a mixture of glass beads and a synthetic fiber resin through a spinneret, the beads being vacuum-metalized with a material having a reflection function. The process further comprising the steps of positioning an electric field around the spinneret, and passing the filament through the electric field before the filament is solidified, whereby the glass beads in the filament rotate so that the metalized parts of the glass beads all point in a same direction.

According to a further aspect of the invention, the recurrent reflective synthetic filament yarn product has substantially 5 to 25 wt% of the glass beads.

According to a further aspect of the invention, each

of the glass beads is a spherical shape having a bead size of 30 to 50 μm, and a refractive index of 1.5 to 2.2.

According to a further aspect of the invention, the material has the reflective function is selected from the group consisting of aluminum, nickel, and silver.

According to a second aspect of the invention, a recurrent reflective synthetic filament yarn is disclosed. The filament includes vacuum-metalizing spherical glass beads each having a bead size of 30 to 50 μm and a refractive index of 1.5 to 2.2, wherein 1/4 to 1/2 of an entire surface area of the spherical glass beads are vacuum-metalized with a material, the material having a reflection function. The filament includes a synthetic resin. Five to 25 wt% of the filament is the glass beads and 95 to 75 wt% of the filament being the synthetic fiber resin. The filament is melt-spun through a spinneret. The yarn is produced by the following method including the steps of passing the filaments through an electric field around the spinneret before the filaments are solidified, so as to rotate the glass beads contained in the filaments such that metalized parts of the glass beads all point in a same direction.

According to a further aspect of the invention, the spinneret having a nozzle and nozzle holes, and the method comprising the step of installing a positive plate and a

negative plate under the nozzle holes of the spinneret such that the positive plate and the negative plate face each other and are spaced from each other at an interval of one to five mm. The method further comprising the step of applying a voltage of 3000 to 20000 V and a current of three to five mA to the positive plate and negative plate, thereby forming the electric field.

According to a further aspect of the invention, the nozzle holes of the spinneret are aligned in one or two rows.

According to a further aspect of the invention, the method comprises the step of adding 0.2 to 0.5 wt% of dioctylphthalate as a softener and 0.2 to 0.5 wt% of Ca antiadditive as a dispersing agent into the synthetic fiber resin to uniformly mix the glass beads with the synthetic fiber resin, to provide softness to the synthetic fiber resin during the melt-spinning of a mixture of the glass beads and synthetic fiber resin, and to improve the softness of the recurrent reflective synthetic filament yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 schematically illustrates a mechanism of reflection of light in a conventional reflective yarn;

FIG. 2 schematically illustrates a mechanism of reflection of light in slit thread or fabric produced using the conventional reflective yarn;

FIGS. 3 and 4 schematically illustrate a mechanism of reflection of light in an omnidirectional reflective filament yarn (synthetic fiber filament) according to the present invention;

FIG. 5 schematically illustrates a mechanism of reflection of light in the omnidirectional reflective hollow filament yarn (synthetic fiber filament) according to the present invention;

FIG. 6 illustrates one filament of a recurrent reflective filament yarn according to the present invention;

FIG. 7 illustrates the alignment of glass beads in each filament of the recurrent reflective filament yarn according to the present invention;

FIG. 8 is a plan view of an end of a spinneret for spinning the recurrent reflective filament yarn according to the present invention; and

FIG. 9 illustrates a perspective view of the recurrent reflective filament yarn according to the present invention, and a sectional view taken in the direction of the arrows along the line A-A′ of the recurrent reflective filament

yarn.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawing.

A recurrent reflective synthetic filament yarn according to the present invention is characterized in that it includes 5 to 25 wt% glass beads in which 1/4 to 1/2 of a surface area of the glass beads are vacuum-metalized with a material having reflective function.

Additionally, the present invention provides the recurrent reflective synthetic filament yarn including 5 to 25 wt% glass beads in which 1/4 to 1/2 of the surface area of the glass beads are vacuum-metalized with the material having the reflective function, characterized in that such glass beads are aligned so that metalized parts of the glass beads all point in the same direction.

Furthermore, the present invention provides a method of producing the recurrent reflective synthetic filament yarn, including vacuum-metalizing the material having the reflective function on surfaces of the spherical glass beads with a bead size of 30 to 50 μm and a refractive index of 1.5 to 2.2 such that 1/4 to 1/2 of surface areas of the

spherical glass beads are vacuum-metalized with the material having the reflective function, and melt-spinning the resulting glass beads in conjunction with a synthetic resin having a fiber formative function (hereinafter, referred to as "synthetic fiber resin") after such glass beads are uniformly mixed with the synthetic fiber resin, or melt-spinning such glass beads and the synthetic fiber resin mixed with each other while a spun filament yarn passes through an electric field to align the glass beads contained in the filament yarn so that metalized parts of the glass beads all point in the same direction, before the spun filament yarn is solidified.

The recurrent reflective synthetic filament yarn according to the present invention has a structure that the spherical glass beads 20 vacuum-metalized with the material having the reflective function are uniformly dispersed in the filament yarn 10 as shown in FIGS. 3 to 5, or alternatively, has a structure that the metalized parts 22 of the spherical glass beads 20 vacuum-metalized with the material having the reflective function all point in the same direction as shown in FIG. 6.

Particularly, in the case of the recurrent reflective synthetic filament yarn 10 in which the metalized parts 22 of the spherical glass beads 20 all point in the same direction as shown in FIG. 6, the metalized parts 22 of the

glass beads 20 all face in a direction perpendicular to an axis of the filament yarn 10, thus when a unidirectional beam such as light irradiated from the front lights of automobiles is irradiated to the filament yarn 10, all of the glass beads 20 retroreflect the light in the same direction.

The metalized glass beads 20, a part of the surface of which is vacuum-metalized with the material having the reflective function, should take a shape of a sphere so that the irregular reflection and recurrent reflection occur in a slit thread produced using the metalized glass beads 20, thereby an effect of the reflection is sufficiently achieved.

The glass beads 20, 40 useful in the present invention are 30 to 50 μm in terms of the bead size. For example, when the bead size is less than 30 μm, recurrent reflection and irregular reflection effects are good, the glass beads 20, 40 are easily mixed with the synthetic fiber resin because the glass beads are sufficiently compatible with the synthetic fiber resin, and the dispersibility and lubricating ability are not largely reduced. However, it is difficult and not economical to produce the glass beads with the low bead size while each of the glass beads maintains a spherical shape. On the other hand, when the bead size is more than 50 μm, the slit thread produced using the glass beads is too thick, the glass beads are not sufficiently

mixed with the synthetic fiber resin because the glass beads are not sufficiently compatible to the synthetic fiber resin, and the dispersibility and lubricating ability are greatly reduced, and thus it is difficult to produce yarn using the glass beads.

Furthermore, it is preferable that the refractive index of each glass bead is 1.5 to 2.2. The reason for this is that the optimum refractive index of the glass bead is preferably determined in conformity to a refractive index of the synthetic fiber resin 30 because when the light is irradiated to the synthetic fiber resin 30, the light is refracted by the synthetic fiber resin 30, advances into the glass beads 20, is reflected by the metalized parts 22 of the glass beads 20, and passes through the synthetic fiber resin 30. Accordingly, illustrative, but non-limiting components of the glass bead include 10 to 15 % of TiO_2 (titanium dioxide) and BaO (barium oxide) and 85 to 90 % of SiO_2 (silicon oxide).

As described above, the glass beads of the present invention are partially vacuum-metalized with the material having the reflective function on surfaces thereof. In this respect, the material having the reflective function may be made of highly pure metal materials such as titanium, chromium, silver, or aluminum. In consideration of reflection efficiency, specific weight, ease of metalization,

metalization property, and particularly conductivity and economic efficiency, it is most preferable to use aluminum as the material having the reflective function.

The metalized parts of the glass beads vacuum-metalized with the material having the reflective function act as a reflective film to retroreflect the light. Accordingly, the "reflective film" means the "metalized parts" of the glass beads, which are formed by vacuum-metalizing 1/4 to 1/2 of surface areas of the spherical glass beads with the material having the reflective function. In the case of using only non-metalized glass beads, the reflective index of each glass bead is 10 to 20 $cd/lx \cdot m^2$. On the other hand, in the case of using the glass beads of which the surfaces are partially vacuum-metalized with aluminum, the reflective index is 450 to 600 $cd/lx \cdot m^2$, and average 500 to 550 $cd/lx \cdot m^2$.

The reflective film may be formed on the surfaces of the glass beads with the use of the material having the reflective function according to various Vacuum Metalization processes such as Vacuum Metalization, Ion Plating, Sputtering, Vapor Plating, Evaporation, Ion-beam, Molecular Beam Epitaxy, and ARE. As will be appreciated by those skilled in the art, the reflective film, in particular, the aluminum reflective film can be easily formed on the glass beads. For example, a polyethylene terephthalate (PET)

sheet is coated with polyethylene to a thickness of 2 to 25 μm and then a silane silicone coating agent in an amount of two to five g/m^2. The glass beads are uniformly dispersed on the resulting PET sheet with the use of a vibrator, and thereafter, the glass beads are sunk by a heat roller to 3/4 to 1/2 volume into the resulting PET sheet. Finally, the glass beads are metalized with aluminum in conformity to a predetermined vacuum-metalizing process, thereby accomplishing the aluminum metalized parts of the glass beads reflecting the light.

Additionally, it is preferable that the metalized parts 22 of the metalized glass beads 20 occupy 1/4 to 1/2 of the entire surface area of the glass beads. For example, when the surface area of the metalized part is less than 1/4 of the entire glass beads surface area, the reflective index is reduced because a percentage of light reflected as the recurrent reflection is small, and breakage of yarn easily occurs because a great number of glass beads are used to obtain the sufficient reflective index, and because mostly only the irregular reflection occurs. Furthermore, the filament yarn produced using the glass beads has poor texture and is insufficiently competitive in terms of production costs. On the other hand, when the surface area of the metalized part is more than 1/2 of the entire glass beads surface area, the reflective film cannot be easily

formed, the reflective index is reduced because an amount of the retroreflected light is small, and the expense to metalize the glass beads is large, thus the glass beads of which the metalized part occupies an area more than 1/2 of the entire glass bead surface area are not economical to use in the production of the filament yarn.

It is effective to use the metalized glass beads 20 in an amount of 5 to 25 wt% to produce the filament yarn. For example, when an amount of the metalized glass beads 20 is less than 5 wt%, a reflection effect cannot be sufficiently obtained. On the other hand, when the amount is more than 25 wt%, an improvement of the reflection effect by the excessive amount of the metalized glass beads 20 is a little.

Meanwhile, the synthetic fiber resin may be made of any synthetic resin with fiber formative function, and illustrative, but non-limiting examples of the synthetic fiber resin used in the present invention include polyester, polyamide (Nylon), vinylon, acryl, polyolefin, vinyl chloride, vinylidene chloride, and urethane.

A dispersing agent and a softner are used so as to prevent a reduction of dispersibility of the glass beads 20 in the synthetic fiber resin 30 during a melt-spinning step because the metalized glass beads 20 and non-metalized glass beads 40 are incompatible with the synthetic fiber resin 30, and because it is difficult to produce the filament yarn

using the glass beads due to its poor softness. In other words, the metalized glass beads 20 have three to five times higher specific weight than the synthetic fiber resin 30, that is, the specific weight of the metalized glass beads 20 is 4.2, thus 0.2 to 0.5 wt% softner is added to the synthetic fiber resin 30 to uniformly mix the glass beads 20 with the synthetic fiber resin 30, to provide softness to the synthetic fiber resin 30, and to improve the softness of the filament yarn produced with the use of the glass beads 20 and synthetic fiber resin 30. Furthermore, 0.2 to 0.5 wt% dispersing agent is added to the synthetic fiber resin to uniformly mix the metalized glass beads 20 with the synthetic fiber resin 30 in an extruder.

Any softner and dispersing agent generally used in the art may be used to produce the filament yarn according to the present invention, and it is most preferable that dioctyl phthalate (DOP) is used as the softner and Ca antiadditive is used as the dispersing agent. If an amount of the softner or the dispersing agent deviates from a range of 0.2 to 0.5 wt%, a desired effect is insufficiently secured or an addition effect of the softner or the dispersing agent into the synthetic fiber resin is not greatly improved, thus use of the softner or the dispersing agent is not economical, and physical properties of the filament yarn produced using the glass beads and synthetic

fiber resin are reduced.

Further, 0.2 to 0.5 wt% various performance improvers such as a UV shielding agent, an antistatic agent, an aromatic agent, an odor removing agent, and a deodorant may be additionally used to produce the filament yarn in order to improve various physical properties of the filament yarn, and to improve economic efficiency.

According to the present invention, only the metalized glass beads 20 may be used to improve the desired reflection effect, but any one of the non-metalized glass beads 40 and/or pearl beads 50, or a combination thereof may be used in conjunction with the metalized glass beads 20 to further improve the reflection effect. In this respect, it is preferable that a material of the non-metalized glass beads 40 is the same as that of the metalized glass beads 20. When the non-metalized glass beads 40 are added to the synthetic fiber resin 30, the light is refracted by the non-metalized glass beads 40. When the refracted light is irradiated into a non-metalized part 21 of the metalized glass beads 20, the recurrent reflection occurs by the metalized part 22 of the metalzied glass beads 20, thereby the filament yarn has an improved reflection effect. As for the pearl beads 50, they are used as a reflector with a diameter of 30 to 50 μm. The pearl beads 50 have poorer reflection brightness than the metalized glass beads 20.

However, when the pearl beads 50 are used in conjunction with the metalized glass beads 20, they have the desired reflection effect and can show various colors with the use of various pigments, thereby they can be used in various applications. For example, the pearl beads can sufficiently show combined colors of red, yellow, blue, black, and white etc., thus it is useful in clothes, bags, and footwear applications. Meanwhile, it is preferable that a total amount of the metalized glass beads 20, the non-metalized glass beads 40, and/or the pearl beads 50 added to the synthetic fiber resin 30 is not more than 35 wt%. If the total amount is more than 35 wt%, the formation of the filament yarn is not smoothly conducted due to a physical properties difference between the glass beads and the synthetic fiber resin, and there are several disadvantages of breakage of the yarn, difficulties of the spinning of a mixture of the glass beads and synthetic fiber resin, and the reduction of the physical properties, such as tensile strength, of the filament yarn produced using the glass beads. Additionally, it is preferable to use the spherical non-metalized glass beads 40 to secure the desired reflection effect.

A detailed description will be given of a method of producing the recurrent reflective synthetic filament yarn including the glass beads 20, below.

5 to 25 wt% spherical glass beads having the bead size of 30 to 50 ㎛ and the refractive index of 1.5 to 2.2, of which 1/4 to 1/2 of the surface areas are vacuum-metalized with the material having the reflective function, are melt-spun in conjunction with the synthetic fiber resin to produce the omnidirectional reflective yarn structured such that the glass beads 20 are uniformly distributed in the recurrent reflective synthetic filament yarn 10 as shown in FIG. 3.

Additionally, when the recurrent reflective synthetic filament yarn is melt-spun, it passes through an electric field to properly rotate the glass beads 20 vacuum-metalized with the material having the reflective function so that the metalized parts 22 of the glass beads 20 all point in the same direction, before the filament yarn is solidified, thereby producing the recurrent reflective synthetic filament yarn according to the present invention, in which the glass beads 20 are aligned so that the metalized parts 22 of the glass beads 20 all point in the same direction, as shown in FIG. 6.

In detail, as shown in FIG. 7, when the synthetic fiber resin and glass beads are mixed with each other and then melt-spun through a spinneret 11, a negative plate 12 and a positive plate 13 are installed in such a way that the negative and positive plates 12, 13 face to each other. The

unsolidified filament yarn 10 containing the glass beads 20 spun through the spinneret 11 passes through between the positive and negative plates 13, 12, and a direct current source is connected to the negative and positive plates 12, 13 to form the electric field around the filament yarn 10, thereby the glass beads 20 are aligned so that the metalized parts 22 of the glass beads 20 all point in the same direction. When the electric field is formed around the filament yarn 20, free electrons in a metal material of the metalized parts 22 of the glass beads 20 are moved toward the positive plate 13, thus polarizing the glass beads 20, thereby the glass beads 20 ensure an induced dipole moment.

The induced dipole moment leads to the alignment of the free electrons in the electric field toward a positive pole, thus when a mixture of the semi-liquid synthetic fiber resin 30 and glass beads 20 is discharged through the spinneret 11, the glass beads 20 sufficiently rotate in the semi-liquid synthetic fiber resin 30, thereby allowing all of the metalized parts 22 of the glass beads 20 to point in the same direction. According to the present invention, it is preferable that a relatively high DC (direct current) voltage of 3000 to 20000 V and a relatively low current of three to five mA are applied to the negative and positive plates 12, 13 and a distance between the negative and positive plates 12, 13 is one to five mm so as to generate

the desired induced dipole moment.

With reference to FIG. 8, there is illustrated a plan view of an end of the spinneret 11 for spinning the recurrent reflective filament yarns 10 according to the present invention, in which a plurality of nozzle holes are formed in one row or two rows. The reason why the nozzle holes are aligned in one or two rows is that when the filament yarns 10, spun through the nozzle holes aligned in one or two rows, pass between the positive and negative plates 13, 12 while the filament yarns 10 being spaced from the positive and negative plates 13, 12 at the same interval, the glass beads 20 in the filament yarns 10 are evenly affected by the electric field.

Referring to FIG. 9, there is illustrated the recurrent reflective filament yarns according to the present invention. At this time, 18 plies of filaments form one yarn. As illustrated in a sectional view taken in the direction of the arrows along the line A-A′ of the yarn, all of the glass beads 20 are not aligned in the desired direction effective to the recurrent reflection (in the spinning direction of the filament yarns), but a portion of glass beads 20 aligned in the desired direction effective to the recurrent reflection contribute to the recurrent reflection of the filament yarn.

Accordingly, the filament yarns of the present

invention, in which the metalized parts 22 of the glass beads 20 point in the same direction, act as the recurrent reflective yarn, and if the filament yarns of the present invention are mixed with other filament yarns, the light recurrently reflected by the filament yarn of the present invention is again recurrently reflected by the other filament yarns, thereby realizing an omnidirectional reflection effect.

A better understanding of the present invention may be obtained in light of the following examples which are set forth to illustrate, but are not to be construed to limit the present invention.

EXAMPLE 1

To produce polypropylene (PP) filament yarn having the omnidirectional reflection function, 1/3 of a surface area of glass beads with an average bead size of 40 μm and a bead size distribution of 30 to 50 μm was vacuum-metalized with aluminum to produce metalized glass beads. 85 wt% polypropylene resin was added in conjunction with 0.5 wt% dioctylphthalate based on the polypropylene resin into a stirrer, then stirred at a rotation speed of 100 rpm for 30 min to form a thin oil film on a surface of the polypropylene resin. 15 wt% metalized glass beads were

added into the stirrer and stirred at the rotation speed of 100 rpm for 30 min. At this time, the metalized glass beads were uniformly distributed on the surface of the polypropylene resin by oil components of the oil film formed on the surface of the polypropylene resin. The resulting resin including the glass beads according to the present invention may be melt-spun without a traditional master batch. In the present invention, production costs of the polypropylene filament yarn are relatively low because it is not necessary to produce the master batch, and a transparent slit thread is produced because the degradation of the polypropylene resin caused by the extrusion for producing the master batch is prevented. The resulting polypropylene resin including the glass beads was melt-spun using an extruder at 210□ at an extruding speed of 600 to 800 m/min to produce an undrawn filament yarn of 430 deniers /18 filaments, then drawn 2.3 times longer by use of a drawing machine to produce a drawn filament yarn of 180 deniers with tenacity of 3 g/denier.

EXAMPLE 2

To produce a polyester (PET) filament yarn having the omnidirectional reflection function, a polyethylene terephthalate resin with an intrinsic viscosity of 0.77 and

the metalized glass beads of example 1 were sufficiently dried in two different driers, respectively, for 10 hours so that moisture contents reached 25 ppm or lower. The dried metalized glass beads were added through a side feeder into an extruder in an amount of 15 wt% while the dried polyethylene terephthalate resin was discharged from the extruder at 285□ at an extruding speed of 600 to 800 m/min to produce undrawn filament yarn of 450 deniers/18 filaments. The undrawn filament yarn was then drawn 2.1 times longer by use of a drawing machine to produce a drawn filament yarn of 200 deniers with tenacity of 3.0 g/denier.

EXAMPLE 3

To produce a PET filament yarn having the omnidirectional reflection function, a polyethylene terephthalate resin with the intrinsic viscosity of 0.77 and the metalized glass beads of example 1 were sufficiently dried in two different driers, respectively, for 10 hours so that moisture contents reached 25 ppm or lower. The dried metalized glass beads were then added through a side feeder into an extruder in an amount of 15 wt% while the dried polyethylene terephthalate resin was discharged from the extruder at 285□, then drawn 2.1 times longer by use of two pairs of hot godet rollers to produce a drawn filament yarn

of 200 deniers with tenacity of 3.0 g/denier.

EXAMPLE 4

To produce a polyamide (nylon) filament yarn having the omnidirectional reflection function, dried metalized glass beads were uniformly added through a side feeder into an extruder in an amount of 15 wt% while nylon chips with a relative viscosity of 2.4 were discharged through the extruder at 265□ to produce a polyamide filament yarn of 180 deniers/18 filaments.

EXAMPLES 5 TO 8

Procedures of examples 1 to 4 were repeated except that non-metalized glass beads were additionally added to a synthetic fiber resin in the amount of 5 wt%, thereby synthetic filament yarns were produced. The synthetic filament yarns thus produced had an improved reflection effect, and the reflection effect of light depended on the amount of the metalized and/or non-metalized glass beads in the synthetic filament yarns, thus various synthetic filaments yarns may be produced according to consumer needs by controlling the amount of the metalized and/or non-metalized glass beads in the synthetic filament yarns.

EXAMPLE 9

An undrawn filament yarn melt-spun according to the same procedure as example 1 was drawn by use of a drawing machine and simultaneously cut to produce staple fibers having mono fineness of 7 denier and length of 52 mm. Then, the staple fibers thus produced were heat-treated with the use of a calender roll at 145□ to produce non-woven fabrics with a thickness of 0.13 mm. Alternatively, the non-woven fabrics were produced with the use of the staple fibers according to a conventional heat fusion process, as in a conventional fiber production process, and the non-woven fabrics were suitable to use as the alternative of PET based rigid reflective clothes and had good workability. The non-woven fabrics were advantageous in that they were suitable to use as a very soft fiber, in comparison with a conventional PET sheet, (both sides of the sheet were coated with an aluminum reflector and glass beads, respectively, to have the recurrent reflection function), or a conventional PVC sheet, thus the non-woven fabrics can be extensively applied to various applications such as safety clothing or safety signs.

EXAMPLES 10 TO 18

Procedures of examples 1 to 9 were repeated except that the non-metalized glass beads were uniformly mixed with the pearl beads in a weight ratio of 70:30 and the resulting mixture was added through a side feeder in conjunction with yellow pigment master chips into an extruder in a proportion of 2 wt%, to produce yarn-died synthetic filament yarns with yellow and pearl colors.

EXAMPLE 19

To produce polypropylene (PP) filament yarn having the recurrent reflection function, 1/3 of surface area of spherical glass beads with an average bead size of 40 μm, a refractive index of 1.5 to 2.2, and a bead size distribution of 30 to 50 μm was vacuum-metalized with aluminum to produce metalized glass beads. 85 wt% polypropylene resin was added in conjunction with 0.5 wt% dioctylphthalate based on the polypropylene resin into a stirrer, then stirred at a rotation speed of 100 rpm for 30 min to form a thin oil film on a surface of the polypropylene resin. 15 wt% metalized glass beads were added into the stirrer and stirred at the rotation speed of 100 rpm for 30 min. At this time, the metalized glass beads were uniformly distributed on the surface of the polypropylene resin by oil components of the

oil film formed on the surface of the polypropylene resin. The resulting polypropylene resin including the glass beads was melt-spun using an extruder at 210□ at an extruding speed of 600 to 800 m/min and simultaneously passed through an electric field around a spinneret (refer to FIG. 7) before filaments spun from the extruder were solidified to produce an undrawn filament yarn of 430 deniers /18 filaments. The undrawn filament yarn was drawn 2.3 times longer by use of a drawing machine to produce a drawn filament yarn of 180 deniers with tenacity of 3 g/denier.

EXAMPLE 20

To produce a polyester (PET) filament yarn having the recurrent reflection function, a polyethylene terephthalate resin with an intrinsic viscosity of 0.77 and the metalized glass beads of example 19 were sufficiently dried in two different driers, respectively, for 10 hours so that moisture contents reached 25 ppm or lower. The dried metalized glass beads were added through a side feeder into an extruder in an amount of 15 wt% while the dried polyethylene terephthalate resin was discharged from the extruder at 285□ at an extruding speed of 600 to 800 m/min and simultaneously passed through an electric field around a spinneret before filaments spun from the extruder were

solidified to produce an undrawn filament yarn of 450 deniers/18 filaments. The undrawn filament yarn was then drawn 2.1 times longer by use of a drawing machine to produce a drawn filament yarn of 200 deniers with tenacity of 3.0 g/denier.

EXAMPLE 21

To produce a PET filament yarn having the recurrent reflection function, a polyethylene terephthalate resin with the intrinsic viscosity of 0.77 and the metalized glass beads of example 19 were sufficiently dried in two different driers, respectively, for 10 hours so that moisture contents reached 25 ppm or lower. The dried metalized glass beads were then added through a side feeder into an extruder in an amount of 15 wt% while the dried polyethylene terephthalate resin was discharged from the extruder at 285□. The resulting resin spun from the extruder passed through an electric field around a spinneret before the resulting resin spun from the extruder were solidified to produce filaments. The filaments were drawn 2.1 times longer by use of two pairs of hot godet rollers to produce a drawn filament yarn of 200 deniers with tenacity of 3.0 g/denier.

EXAMPLE 22

To produce a polyamide (nylon) filament yarn having the recurrent reflection function, dried metalized glass beads were uniformly added through a side feeder into an extruder in an amount of 15 wt% while nylon chips with a relative viscosity of 2.4 were discharged through the extruder at 265□. Filaments spun from the extruder passed through an electric field around a spinneret before the filaments spun from the extruder were solidified to produce a polyamide filament yarn of 180 deniers/18 filaments.

As described above, the present invention provides a recurrent reflective synthetic filament yarn including 5 to 25 wt% spherical glass beads each having a bead size of 30 to 50 μm and a refractive index of 1.5 to 2.2 and vacuum-metalized with a material having the reflection function such that 1/4 to 1/2 of an entire surface area of the glass beads are vacuum-metalized. In this respect, the glass beads are aligned so that metalized parts of the glass beads all point in the same direction. Therefore, the recurrent reflective synthetic filament yarn of the present invention acts as a yarn while securing almost the same reflection efficiency as a conventional slit film or a conventional slit thread. In the production of the conventional film or thread, after an aluminum paste layer as a reflective layer

is coated on any one side of a thin synthetic resin film or sheet, a mixture of transparent polyurethane or an adhesive and the glass beads is coated on the aluminum paste layer to produce the reflective film or sheet, and the reflective film or sheet thus produced is longitudinally slit in such a way that a width of the reflective film or sheet is 0.25 to 0.37 mm in the case of the narrow reflective film or sheet, or 3 to 5 mm in the case of the wide reflective film or sheet. At this time, the conventional slit reflective film or sheet is doubled or twisted with a synthetic yarn to produce the slit thread.

Accordingly, the recurrent reflective synthetic filament yarn of the present invention has superior texture and improved workability, and can be applied to a mechanical embroidery, a computer embroidery, and a sewing process because the recurrent reflective synthetic filament yarn can be used as an embroidery yarn. Furthermore, it has the superior color fastness to washing and the washing of the filament yarn can be easily conducted. As well, the filament yarn is not changed after the washing in views of the physical properties, applied to various applications, produced in commercial quantity, and very competitive in terms of production costs.

In the following table 1, there are described brightnesses of woven fabrics, produced using the filaments

of examples 19 to 22 of the present invention, according to an Europe EN471 standard, and the brightnesses of the woven fabrics in the case of using the desirably aligned glass beads are compared with those of the woven fabrics in the case of using the glass beads without being aligned. The measurement of light is conducted under conditions of an incidence angle of 5 degrees and an observation angle of 0.2 degrees.

TABLE 1

Example	Reflection performance {cd/(lux·m^2)}	
	Desirably aligned glass beads	Non-aligned glass beads
19	280	130
20	250	100
21	260	120
22	240	90

From the table 1, it can be seen that the brightness of the woven fabric in the case of using the glass beads desirably aligned in each filament is improved by 100 % or more in comparison with that of the woven fabric in the case of using the glass beads without being aligned.

The present invention has been described in an illustrative manner, and it is to be understood that the

terminology used is intended to be in the nature of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. Therefore, it is to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.